Department of Orthopaedic Surgery and Rehabilitation

Wake Forest School of Medicine

32nd Annual Gary Poehling, MD Resident Research Day

3rd Beth and Tom Smith Visiting Professor

John M. Flynn, MD

June 23, 2023

Atrium Health Wake Forest Baptist

Wake Forest University School of Medicine

The Department of Orthopaedic Surgery Resident Research Day and Visiting Professor is a yearly event where PGY3, PGY5, and Physician Scientists highlight their research through podium presentations. Monetary awards are given to the top basic science and top clinical research projects. Recipients are selected based on the overall evaluation of their research project and scored by the Visiting Professor.

The Visiting Professor highlights the event with presentations that provide insight on the technical aspects of their research and advising residents on how to transition from residency to fellowships to a faculty position. The Visiting Professor is an esteemed colleague in an orthopaedic specialty. This year's Visiting Professor is an expert in Pediatric Orthopaedics and invited by Dr. Michael Hughes, Assistant Professor, and Orthopaedic Surgery.

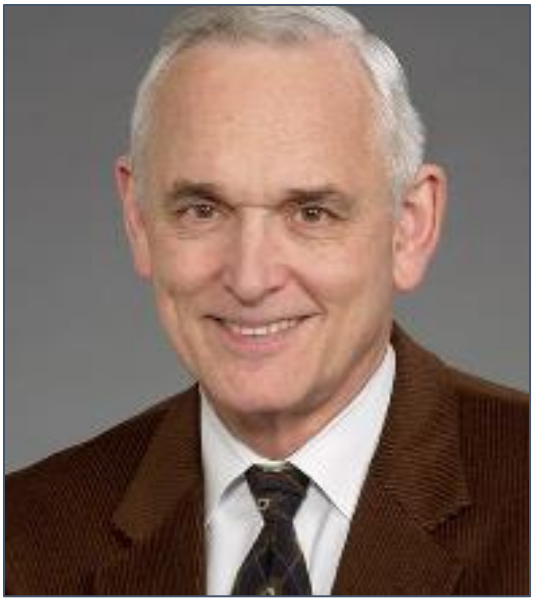
John M. "Jack" Flynn, MD
3rd Beth and Tom Smith Visiting Professor

Jack is the Chief of Orthopaedic Surgery at The Children's Hospital of Philadelphia and Professor of Orthopaedic Surgery at the University of Pennsylvania. He went to Johns Hopkins University to play football and baseball and met his wife Mary the first week of college. Next Pittsburgh—for Jack's med school, Mary's Masters in Applied Mathematics, and marriage. Next Boston: Harvard Combined Orthopaedic Surgery Program 1989-1995, Chief Residency at Boston Children's 1995, Mary's career and 2 children. Next, a Fellowship at DuPont Hospital for Children (1 more baby), then CHOP in 1996 (1 more baby).

Jack's clinical focus includes pediatric spine deformity, early onset scoliosis/thoracic insufficiency, fractures and hip disorders. He is the author of over 300 peer reviewed papers, reviews and chapters, and Editor of the seminal texts in pediatric orthopaedics: Lovell and Winter's Pediatric Orthopaedics, Rockwood's Fractures in Children, Operative Techniques in Pediatric Orthopaedics and Staying Out of Trouble in Pediatric Orthopaedics. A winner of multiple teaching awards, Jack lectures nationally and internationally on management of spinal disorders, pediatric fracture care, safety and value in spine care, and life-work integration for surgeons. Jack has served as President of Pediatric Orthopaedic Society of North America, Chair of the International Pediatric Orthopaedic Symposium, President of the Children's Spine Study Group and Vice President of the American Board of Orthopaedic Surgery. He is currently President of the Pediatric Spine Foundation, and serves on the Board of Trustees for JBJS.

Jack and Mary have been married for over 35 years, and are the embarrassingly proud parents of Erin (31), Colleen (28), John (26), and Kelly (23) and granddaughter Emma

Gary G. Poehling, M.D.



Dr. Gary G. Poehling received a B.S. degree from Marquette University in 1964 and his M.D. degree from Marquette School of Medicine in 1968. He completed an internship and residency in general and thoracic surgery at Duke Medical Center from 1968-1970. He served in the United States Air Force from 1970-1972 at the 655th Tactical Hospital in Tachikawa, Japan. After fulfilling his military duty, Dr. Poehling completed his orthopaedic residency at Duke Medical Center from 1972-1976, serving as Chief Resident his final year. He subsequently joined the faculty of Bowman Gray School of Medicine, now Wake Forest University School of Medicine, and Department of Orthopaedic Surgery as an Assistant Professor. Dr. Poehling served as Interim Chair of the Department in January 1989 and was formally appointed as Chair in October 1989 and served in that capacity for 18 years and served as Editor in Chief for the Journal of Arthroscopy for 24 years.

Dr. Poehling has over 43years of experience as an orthopaedic surgeon. He pioneered the use of arthroscopy and was influential in defining various procedures that can be performed arthroscopically. Together with James Roth, MD and Terry Whipple, MD, Dr. Poehling pioneered the use of wrist arthroscopy in 1985. Dr. Poehling also was one of the first orthopaedic surgeons to use arthroscopic operative techniques in the elbow. Dr. Poehling has also served as a proponent for the development and use of minimally invasive surgical techniques. As an academic surgeon he has promoted the application of computer technology for training residents and medical students. He has championed the importance of orthopaedic outcome studies and evidence-based medicine.

Beth Smith, PhD and Thomas Smith, PhD

Beth Smith earned her PhD in Toxicology from Texas A&M in 1974. She completed post-doctoral work at Wake Forest School of Medicine in 1978 with Richard St. Clair, PhD. Dr. Smith began her career at Wake Forest School of Medicine in 1987 in the Department of Orthopaedic Surgery as a Research Assistant. Her research interests were botulinum toxin to treat cerebral palsy. Her work using intramuscular toxin injections to manage muscle spasticity changed the management of pediatric patients with cerebral palsy worldwide. Dr. Smith published journal articles, book chapters, and books throughout her career. During her tenure, she was the Director of the Orthopaedic Research Lab, Coordinator of the Spasticity Management Workshops, served as Chair of the Division of Surgical Sciences Research Day from 1993-1997, and Chair of the Department of Orthopaedic Surgery Resident Research Day from 1991 until her retirement in 2018.

Thomas Smith earned his PhD in Physiology from Bowman Gray School of Medicine in 1979. He completed post-doctoral work at the University of Mississippi School of Medicine with Thomas Coleman, PhD and Arthur C. Guyton, PhD. Dr. Smith served as an Assistant Professor in the Department of Physiology and Biophysics at the University of Mississippi School of Medicine from 1980-1982. He began his career at Wake Forest School of Medicine as an Instructor in the Department of Physiology and Pharmacology in 1978, achieving the rank of Assistant Professor in 1982. Dr. Smith joined the Department of Orthopaedic Surgery in 1996 working diligently to improve orthopaedic research until his retirement in 2020. He is an expert in small animal models and microsurgery training. The models he developed are now a resource for the IACUC and multiple collaborators across the institution. His expertise in cardiovascular physiology and applications for orthopaedic research helped establish the Extremity Lab, advanced techniques for re-implantation, and assessment of compartment syndrome. He collaborated with Walt Curl, MD, and Nicole Deal to determine the action mechanism of cold therapy for treatment of contusions. Dr Smith published journal articles, book chapters, and books throughout her career.

Beth Smith, PhD, and Tom Smith, PhD, have many collaborative accomplishments during their tenure in the Department of Orthopaedic Surgery at Wake Forest University. They were responsible for the growth of industry and grant funding for the lab. With this additional funding, the lab was able to grow the support personnel to facilitate the research interests of the department's faculty and residents. Current personnel comprise 4 research faculty, 4 management level staff, 13 grants, lab, and project coordinator staff members. The Smiths were instrumental in the establishment and success of the Physician Scientists program starting in 1999. The program has resulted in patents, publications, Physician Scientist training, numerous awards, and the establishment of an orthopaedic research lab at Wake Forest School of Medicine that continues to thrive and grow.

- Patents: 3 awarded; 3 pending
- Book Chapters: 38
- Peer reviewed journal articles: 240
- Grant Funding (Pi or Co-I): $19,150,068

Physician Scientists:

- 20 of 13 have completed their PhD; 7 currently serves as faculty at Medical Schools
- MD/PhD's 9 (4 more pending)

Awards

- Koman L, Smith B, Li Z, Smith T. Kappa Delta Award for Clinical Research in Microvascular Physiology. Orthopaedic Research and Education Foundation. American Association of Orthopaedic Surgeons. 1999.
- Koman L, Smith B, Smith T. Kappa Delta Award for Clinical Research in Translational Uses of Botulinum Toxins. Orthopaedic Research and Education Foundation. American Association of Orthopaedic Surgeons. 2019
- Co-authors for 3rd, 4th, and 7th most frequently cited article from the Journal of Pediatric Orthopaedics
- Co-authors for top 100 classic papers of pediatric orthopaedic Surgery in JBJS (19th, 21st, and 30th most frequently cited)

Thirty-Second Annual Gary Poehling, M.D. Resident Research Day
June 23, 2023

Third Annual Beth and Tom Smith Visiting Professor

John M. Flynn, MD
Chief, Division of Orthopaedic Surgery
Richard M. Armstrong, Jr. Endowed Chair in Orthopedic Surgery
Chief of Orthopaedic Surgery, The Children's Hospital of Philadelphia
Professor of Orthopedic Surgery, Perelman School of Medicine at the University of Pennsylvania

8:30	Introduction: Michael Hughes, MD
8:35	John M. Flynn M.D. Presentation: "Orthopaedic Surgeon: What a Great Way to be Useful to Others".
9:15	**BREAK**
Emcee:	Sam Rosas, MD, Ph.D, MBA, (PGY4)
	Physician Scientists:
9:30	Tameka Dean, DO
9:40	Marcel Brown, MD
9:50	Discussion
10:00	**BREAK**
	PGY3:
10:15	Chukwuweike "Ikey" Gwam, MD
10:25	Elliott Voss, MD
10:35	Ameen Barghi, MD
10:45	Alexus Cooper, MD
10:55	Hunter Yancey, MD
11:05	Discussion
11:15	**Lunch**
12:30	John M. Flynn, MD Presentation: "Peak Performance for Surgeons: Managing your Energy, Time and Priorities".
	PGY5:
1:30	Ross McCallie, MD
1:40	Hunter Matthews, MD
1:50	Natalie Marenghi, MD
2:00	Chris Grimes, MD
2:10	Alex Jinnah, MD, PhD
2:20	Discussion
2:30	**BREAK**
2:45	Case Presentations (PGY2 and PGY4)

Inhibition of the PKCβII-P66shc Pathway as a Therapeutic Strategy against Tourniquet-Induced Ischemia-Reperfusion Injury

Dean T, Henry K, De Los Santos M, Healy K, Lion R, Moore C, Sangio C, Murphy J, Cunningham T, Pilson H, Ma X

Introductions: The use of tourniquets for extremity hemorrhage in tactical combat casualty care has significantly reduced mortality. However, prolonged tourniquet application can lead to increased risk of complications, such as muscular atrophy and threatened limb loss, due to ischemia-reperfusion (I/R) injury. Delayed return of blood flow to ischemic muscle leads to mitochondrial dysfunction, increased production of reactive oxygen species (ROS), and cell apoptosis. I/R injury also contributes to the impairment of skeletal muscle stem cells, known as satellite cells, to regenerate damaged muscle and leads to long-term deficits in muscle strength. The purpose of this study is to determine whether inhibition of the pro-oxidant PKCβII-p66shc pathway can mitigate oxidative stress in satellite cells to enhance muscle fiber repair following simulated I/R injury. We hypothesize that Ruboxistaurin (RBX), a selective PKCβII inhibitor, will decrease mitochondrial ROS production using an *in vitro* model of chemically induced oxidative stress.

Methods: Phorbol 12-myristate 13-acetate (PMA) was used to stimulate ROS production in C2C12 myoblasts (i.e., activated satellite cells) with and without RBX pre-treatment. Cells were incubated with 2,2'7-dichlorofluorescin (DCFH) for PMA-induced ROS detection with a fluorescent microplate reader. Cell viability was assessed using a colorimetric assay and microplate reader to determine toxicity of treatments. Live-cell imaging was performed with Hoechst nuclear stain, DCFH, and Mitosox for visualization of nuclei and ROS regions of interest using fluorescent microscopy. Fluorescence intensity was quantified into corrected total cell fluorescence (CTCF) units using ImageJ software. The CTCF units were calculated as follows: integrated density – (area of selected cell x mean fluorescence background). All data were analyzed using the student-test and ANOVA Tukey method.

Results: PMA stimulation resulted in a four-fold increase in ROS levels compared to untreated controls ($p<0.05$). Cell viability was similar in all test groups. RBX significantly decreased intracellular ROS levels in DCFH-stained cells by 45%, from 9578±737 to 5282±1306 CTCF units ($p<0.05$). Mitosox-stained cells treated with RBX demonstrated a 61% reduction in mitochondrial ROS levels (59±4 vs. 151±31 CTCF units) compared to PMA controls ($p<0.05$). CTCF units for nuclei regions of interest were similar for all PMA and RBX-treated samples.

Conclusion: The data suggests that RBX attenuates PMA-stimulated ROS production in myoblasts. Reductions in ROS were not likely due to cell death since neither PMA nor RBX were toxic to cells. PKCβII inhibition may represent a novel therapeutic approach for the prevention of tourniquet I/R injury in settings of prolonged tourniquet applicaton. In future studies, we will compare Western blots of cytosolic and membrane fractions to confirm the mechanism of RBX to inhibit PKCβII redistribution and subsequent p66shc activity in C2C12 myoblasts. We will also test the effects of RBX on muscle fiber regeneration after 24h hypoxic injury.

Amniotic Fluid Stem Cell Conditioned Media for Treating PTOA in a Rat Model and Primary Human Knee OA *In-Vitro*

Marcel Brown, MD1, Matthew Gwilt, BS, MS1, Leslie Granados1, Jacob Hamby, BA1, Xue Ma, MD, PhD1
1Wake Forest University School of Medicine, Department of Orthopaedic Surgery and Rehabilitation

Introduction: Amniotic fluid stem cells (AFSCs) have the potential to be a promising new treatment for both Osteoarthritis (OA) and Posttraumatic Osteoarthritis (PTOA). AFSCs derive much of their therapeutic potential from the growth factors and cytokines they contain. These growth factors and cytokines can be isolated in the media of conditioned AFSCs. Preclinical and clinical studies with intra-articular injections of AFSC-conditioned media (AFSC-CM) have shown mitigation of PTOA and OA symptoms. In this study, we used a rat PTOA model to evaluate the effects of AFSC-CM on functional and histological outcomes and measured cytokine levels to elucidate the inflammatory pathway AFSC-CM specifically targets. AFSC-CM was additionally assessed in terms of its effects on cell viability *in-vitro* on diseased human knee cartilage and meniscal cells.

Methods: All animals used for the study were approved by IACUC at Wake Forest University School of Medicine. PTOA was introduced in both female and male rat cohorts (n=12 per group) with destabilization of the medial meniscus (DMM) and anterior cruciate ligament (ACL) transection of the left knee. Intra-articular injection of AFSC-CM or saline was administrated at 2 weeks post injury. Animals were followed up for 1, 2, or 3 months for outcomes (n=4 per time point in AFSC-CM and saline group, respectively). Knees were decalcified, embedded then sectioned for histological staining. Slides were stained with hematoxylin and eosin (H&E; Abcam) and safranin-O (SigmaAldrich) for Articular Cartilage Structure (ACS) scoring to evaluate arthritis severity. Multiplex cytokine analysis was performed on serum at different time points following treatment. Unpaired and paired *t*-tests were performed on ACS scores. *T*- tests were also performed on cytokine levels at 2 weeks post injury prior to treatment.
Translation to human tissue was assessed using human knee cartilage and meniscal samples (n=3 per group) collected following total knee arthroplasty in patients with end-stage OA. Cartilage and meniscal cells were cultured in 10% Fetal Bovine Serum (FBS) and treated once after 30% confluence at varying doses of AFSC-CM (10ug/ml, 50ug/ml, 3mg/ml, 10mg/ml and 20mg/ml) in 5% FBS for 6 days and additionally cocultured with IL-1β at 10ng/ml. Unpaired *T*-test were performed on OD values to assess cell viability. Probability level less than 0.05 was considered significant.

Results: ACS score comparing safranin-O staining of medial tibial plateau cartilage between AFSC-CM and saline treatments at 1 month (AFSC-CM vs. Saline, p=0.417), 2 months (AFSC-CM vs. Saline, p=0.0489) and at 3 months (AFSC-CM vs. Saline, p=0.686) showed decreased ACS score with AFSC-CM treatment at 2 months. There was decreased IL-1α at 1 month (AFSC-CM vs. Saline, p=0.041) and TNFα at 3 months (AFSC-CM vs. Saline, p=0.023) with AFSC-CM in comparison to pre-treatment level. Following single-dose administration of AFSC-CM, both chondrocyte and meniscal cell proliferation increased in a dose-dependent manner with significance found at a dose of 3mg/ml and greater (Figure 2).

Conclusion: There was improved cartilage structure at 2 months on histological safranin-O staining with superior preservation of cartilage in the AFSC-CM treated group compared to saline control, which had obvious compromise of the tibial cartilage surface and vertical fissures (Figure 1a and 1b). Decrease in cytokine inflammation *in-vivo* was significant at 3 months for TNF-α and at 1 month for IL-1α demonstrating a promising response to AFSC-CM treatment given the widely reported effects of TNF-α and IL-1α driving OA pathology. The cartilage preserving effect of AFSC-CM translated to human knee cartilage *in-vitro* in a dose dependent manner with treatment promoting cartilage cell viability/growth over time.

Amniotic Fluid Stem Cell Secretome Promotes Schwann Cell Proliferation and Viability via upregulation of cellular antioxidants on a Hydrogel coated Nerve Conduit.

Chukwuweike Gwam MD, MBA
Xue Ma MD, PhD

Introduction: Peripheral nerve injury is a debilitating condition associated with significant morbidity, often requiring surgical intervention for repair. However, the recovery of peripheral nerve function remains unpredictable. Schwann cells (SCs) play a crucial role in nerve healing, and their viability and activity are essential for successful regeneration. Oxidative stress-induced Schwann cell burnout and stress-induced premature senescence (SIPS) have been identified as obstacles to peripheral nerve recovery. Amniotic fluid stem cell secretome (AFS-CM), known for its ability to maintain cellular redox homeostasis and promote proliferation and viability, has emerged as a potential therapy in regenerative medicine. This study investigates the impact of AFS-CM on SC viability and proliferation under normal and oxidative stress conditions. Additionally, we explore SC adherence and proliferation on a hydrogel-coated nerve conduit with AFS-CM treatment, evaluate its role in enhancing cellular antioxidant activity, and examine its protective effect against SIPS development.

Methods: Primary rat SCs were cultured on a hydrogel-coated 96-well plate and treated with varying doses of AFS-CM. Cell analysis was conducted at different time points. To assess the protective role of AFS-CM against oxidative stress, primary SCs were pretreated with AFS-CM and then exposed to hydrogen peroxide (H2O2), followed by evaluation at 24 and 48 hours. SC viability on a hydrogel-coated scaffold was assessed at 48 hours. Intracellular reactive oxygen species (ROS) and cellular antioxidants were measured in SCs pretreated with different doses of AFS-CM and subjected to H2O2-induced oxidative stress. Furthermore, the rate of SCs transitioning to SIPS under oxidative stress was determined after pretreatment with AFS-CM.

Results: AFS-CM dose-dependently increased the proliferation and viability of primary rat SCs under normal conditions. AFS-CM exhibited a protective effect against H2O2-induced oxidative stress at 24 and 48 hours. Confocal microscopy revealed improved survival, adherence, and proliferation of SCs on a hydrogel-coated nerve scaffold compared to the control group. Quantification of ROS and cellular antioxidants demonstrated reduced ROS levels and enhanced cellular antioxidant activity in SCs pretreated with AFS-CM under oxidative stress.

Conclusion: AFS-CM promotes the survival and proliferation of SCs under both normal and oxidative stress conditions, while mitigating the development of SIPS through the upregulation of cellular antioxidants. Further in vivo studies are necessary to assess the therapeutic potential of AFS-CM in peripheral nerve injuries.

Geriatric Distal Femur Fractures Treated with Arthroplasty Are Associated with Lower Mortality but Greater Costs Compared To Open Reduction and Internal Fixation

Elliott Voss, Chukwuweike Gwam, Kristen Harmody, Samuel Rosas, Johannes F. Plates

Introduction: Distal femur fractures (DFF) are common injuries with significant morbidity. Surgical options include operative reduction and internal fixation (ORIF) with plates and/or intra medullary devices or a distal femur endoprosthesis (DFR). A paucity of studies exist that compare the two modalities. The present study utilized a 1:2 propensity score match to compare 30-day outcomes of geriatric patients with distal femur fracture that either underwent an ORIF or DFR.

Methods: The NSQIP data from 2008 to 2019 was utilized to identify all patients who sustained a DFF and underwent either ORIF or DFR. This yielded a total of 3,197 patients who underwent an ORIF vs 121 patients who underwent a DFR. A final sample of 363 patients (242 patients with ORIF vs 121 with DFR) was obtained after a 1:2 propensity score match. Costs were obtained from the national inpatient sample database using multiple regression analysis and validated with a 7:3 train-test algorithm. Independent samples t-tests and chi-square analysis were conducted to assess difference in costs and outcomes respectively.

Results: Patients who received a DFR had higher rates of transfusion compared ORIF ($p= 0.021$) and higher mean inpatient hospital costs ($p= 0.001$). Subgroup analysis for patients 80 or older revealed higher 30-day unplanned readmission and 30-day mortality rates for patients undergoing ORIF compared to DFR. The total number of DFR cases needed to prevent one ORIF related 30-day mortality for distal femur replacement for patients 80 years was 6 (95% CI: 3.02 to 19.9). The mean hospital costs associated with preventing one case of death within 30 days from operation by undergoing DFR compared to ORIF was $176,021.39

Conclusion: Our results demonstrate higher rates of transfusion and increased inpatient costs among the DFR cohort compared to ORIF. However, we demonstrate lower rates of mortality for patients 80 and older who underwent DFR vs. ORIF. This suggests that orthopedic surgeons should consider DFR for elderly patients with a DFF given its complication profile.

PTU: a Pre-Procedural Transition Unit to Improve Capacity Management During High Census Times

Barghi, A., Lopiano, K., Pariyadath, M., Emory, C.

Introductions: This study addresses the growing issue of capacity constraints and limited access to care in tertiary healthcare centers, a problem accentuated by the COVID-19 pandemic. Capacity limitations have led to increased transfer delays and leakage, negatively affecting patient outcomes and prolonging inpatient stays. To combat these challenges, we aimed to (1) establish a dedicated buffer unit, the Pre-procedural Transition Unit (PTU), for patients needing specialty care exclusive to our center, (2) identify the patient population for this unit, (3) devise a process to admit patients directly to the PTU, bypassing Emergency Department and inpatient capacity constraints, and (4) monitor the unit's utilization, safety, and financial implications.

Methods: The Wake Forest Market Regional Operations Center established a Pre-procedural Transition Unit (PTU) to manage patient transfers during severe capacity constraints. Patients requiring urgent procedures within 48 hours are admitted to this five-bed unit with 24/7 specialty nursing care. PTU utilization, operative interventions, patient outcomes, and financial implications are continually analyzed with Round Table Analytics. The data is used to optimize safe PTU transfers, address safety concerns, and expand the PTU concept to other key surgical services and network hospitals. Future analyses will assess patient experience.

Results: The retrospective analysis of the Pre-procedural Transition Unit (PTU) showed significant improvements in various outcomes from July to December 2022. Emergency general surgery had the highest usage of PTU, with 115 admissions, and 70% of PTU patients underwent a procedural encounter. The PTU also had a significant financial impact, with a total gross charge of $33,251,719.09, net revenue of $8,416,305.80, and a direct contribution margin percent of 40%. Compared to 2021 data, PTU significantly shortened times from the start of a transfer to when the patient receives peri-procedural care in specific services, including Orthopedics and Neurosurgery. PTU also reduced length of stay for Vascular & Endovascular Surgery, Neurosurgery, and Cardiothoracic Surgery. The PTU group showed a higher gross charge, net revenue, and operating margin for certain services compared to the control group.

Conclusions: The implementation of our Pre-procedural Transition Unit (PTU) has effectively mitigated capacity constraints, improved patient outcomes, and led to positive financial results at our tertiary care center. With high utilization across various services and a low complication rate, the PTU demonstrated significant efficiency gains compared to a 2021 control group, particularly in reducing procedural and discharge times while increasing revenues. These outcomes affirm the PTU's viability as a model for optimizing healthcare capacity management and enhancing patient care.

Outcomes After Operative Fixation of Tibial Shaft Fractures: Does your patient's home zip code matter?

Alexus M. Cooper, MD; Chukwuweike Uchenna Gwam, MD, MBA; Kaitlin Henry, MPH; Kerry Danelson, PhD; Holly Pilson, MD (Principal)

Introduction: Diaphyseal tibial shaft fractures are the most common long bone fracture. Previous research has established patients of low socioeconomic status present with more complex tibial shaft fractures, earlier exit from the workforce, and worse quality of life Geographic location, and the physical conditions of an individual's living space are a critical component of the host environment which may impact post-operative outcomes. Considering 17 socioeconomic indicators based on an individual's 9-digit zip code, the area deprivation index (ADI) has been demonstrated to be a useful tool in the Orthopaedic Literature to quantify marginalizing factors within a patient's host environment.

This study was developed to assess the socioeconomic and geographic factors that may impact outcomes for patients undergoing operative fixation of tibial shaft fractures at our institution. Accounting for these factors using an ADI score we hypothesized there would be an association between lower ADI scores and limited access to care/poor outcomes for patients undergoing operative fixation of tibial shaft fractures.

Methods: This was a retrospective single-institution study completed with institutional review board approval. Patients who underwent operative fixation of tibial shaft fractures from 2012-2022 under our institution's four fellowship-trained Orthopaedic Trauma Surgeons were identified for the cohort (N=942). Inclusion criteria included patients with at least 1-year follow-up, complete demographic/outcome data, and available 9-digit zip code associated with patient record. This yielded 383 patients. Demographic data, case-specific data, comorbidities, and outcomes were obtained using our institution's electronic medical record. ADI Data was obtained from a publicly sourced dataset out of the University of Wisconsin School of Medicine and Public Health. Scores were assigned to each patient using the 9-digit zip code associated with their home address. Endpoints of interest included 90-day readmission rates, no-show rates, and post-operative complications. Patients were categorized by ADI quartiles followed by data analysis using R software to calculate descriptive statistics. Regression analyses were performed to measure the association of SES as measured by ADI quartile on the endpoints of interest

Results: 383 patients were included in the final data analysis for this study. The average age of patients in this cohort was 48 (SD 19.6). 58% of patients were male, and 74% were Caucasian. There were five patients in the first quartile, 48 in the second quartile, 178 in the second quartile, 178 in the third quartile and 122 in the fourth quartile. There was no association between ADI quartile rank and 90-day readmission and development of postoperative complications. Patients with higher ADI rank demonstrated higher odds of making their post-operative visit ($p<0.001$). Additionally, patients who identified as Black were more likely than their white counterparts to make their post-operative visits, whereas older patients, sicker patients (as measured by Charlson comorbidity index), and male patients were less likely to make their post-operative visits ($p <0.001$).

Conclusion: Preliminary data from this pilot study suggests ADI may serve as a proxy for a patient's ability to access care with worsening ADI rank being associated with increased appointment no-show rates. Further study is needed to assess and identify whether or not this influences a patient's risk additional perioperative complications that affect patient morbidity/mortality. We anticipate data from this study may be used to generate community-based interventions which may target areas of improvement for patient access to care.

Clinical Results of Cannulated Screws and the Femoral Neck System in Stable Geriatric Femoral Neck Fractures

Presenter: Hunter Yancey, MD
Andring, Nicholas MD, Helmig, Kathryn MD, Sowards Gabriel BS, Babcock, Sharon MD, Pilson, Holly MD, Halvorson, Jason MD, Carroll, Eben MD.

Introduction: Femoral neck fractures are one of the most common injuries encountered by an orthopaedic surgeon. While displaced geriatric femoral neck fractures often require arthroplasty, more stable fracture patterns may be amenable to less invasive stabilization. While implants such as cannulated screws (CS) and sliding hip screws (SHS) have greatly improved outcomes over the last several decades there remains room for improvements in implant design. The reoperation rate of patients with femoral neck fractures treated with CS falls within the range of 4-25% likely owing to the varied fracture morphology, bone density and implementation of this implant. Over the last decade multiple hybrid implants have been designed in attempt to combine some of the benefits of both the SHS and CS to increase stability and minimize complications. In recent years Depuy Synthes™ developed the Femoral Neck System™ (FNS) which has a short lateral plate with locking shaft screw connected to a telescoping compressive bolt forming a fixed-angle device like the SHS. Biomechanical studies of the FNS compared to SHS and CS in cadavers have revealed similar performance. In this retrospective series we aimed to determine if early clinical results of the FNS show promising or at least non-inferiority to CS in geriatric femoral neck fractures. Secondary aims included comparing estimated blood loss (EBL) and operative time in patients managed with the FNS versus CS.

Methods: IRB approved the retrospective data collection of geriatric patients with operatively treated femoral neck fractures seen and treated at level one trauma center over a ten-year period (2011-2021). Charts were reviewed for demographic information including age, BMI, medical comorbidities, and use of tobacco products. Pre-injury and intra-operative imaging was used to classify femoral neck fracture morphology and detail concomitant injuries, including stable Garden type 1 and 2 femoral neck fractures typically treated with internal fixation rather than arthroplasty. Operative notes and intra-operative imaging were reviewed to document operative details. Postoperative notes were used to identify post-operative complications and need for reoperation. Student t-tests were used to determine significance between data proportions. Statistical significance was determined by calculating p-values for parameters with significance defined as $p<0.05$.

Results: 36 patients treated with the FNS implant and 56 treated with the CS implant for femoral neck fractures with at least 6 months of radiographic follow up were identified all of which were low energy, stable fracture patterns. The average follow up was 33.6 +/- 22.2 and 44.5 +/- 33.8 weeks for the FNS and CS, respectively. Reoperation rate was statistically different (2.7% for FNS patients versus 25% for CS patients, $p=0.004$). Operative time was not statistically different.

Conclusions: Early results of the FNS implant are promising with similar operative time with potentially lower reoperation rate than CS. More research with larger numbers of patients will be needed to confirm these findings.

Dual Plate Fixation for Periprosthetic Distal Femur Fractures

Andring, N. McCallie, R. Carroll, E.

Introductions: The incidence of distal femur periprosthetic fractures (DFPF) is between 0.3-5%, however, prevalence is expected to continue to grow with an aging population and concurrent increase in knee arthroplasty being performed. Early treatments used simple large fragment plates, however, these reports had relatively high complication rates attributed to lack of angular stability and inadequate distal fixation to support short segments and comminution, particularly on the medial side. With the advent of locked lateral plating angular stability improved with newer plates which provided more distal fixation stability. Unfortunately, there remained a significant amount of hardware failure, nonunion, and need for reoperation despite hardware improvements. A more recent trend in the management has been dual implants consisting of plate-nail (PN) or dual-plate (DP) combinations. Initial biomechanical studies have shown these constructs to have increased axial and torsional stiffness compared to single implant constructs. Both constructs have been found to biomechanically resist axial and torsional strain with higher loads to failure with promising early clinical results in small case series. This study set out to compare DP and single implant (distal femur locking plate – DFLP) fixation of DFPF in one of the largest comparative case series to date and determine the overall reoperation rate, complications, and clinical outcomes between these two constructs.

Methods: The electronic medical record was queried for procedures using codes 27507 and 27511. Adults >50 years old sustaining comminuted OTA 33-A2 or 33-A3 DFPF treated with either DP or distal femur locking plating (DFLP). Intervention consisted of either open treatment of DFPF with DFLP or DP. 34 DFLP and 38 DP patients met inclusion criteria. Main Outcome Measurements were reoperation rate, alignment, and complications. Demographic data were compared by Mann Whitney U and chi square analysis. Outcome prevalence with 95% confidence intervals (95% CI) were calculated for infection, nonunion, malunion, and hardware failure. Outcome rates (95% CI's) were calculated per 10,000 exposure days. Risk ratios and risk difference were calculated to compare dual and lateral implants complications. To compare pre- and post-coronal alignment, analyses of covariance (ANCOVA's) were performed controlled for initial alignment, age, BMI, and diagnosis of osteoporosis or osteopenia.

Results: Average follow up in the DFLP group was 18.2 +/- 13.8 months and 19.8 +/- 16.1 months in the DP group ($p=0.339$). There were no statistical differences in demographics, fracture morphology, loss of reduction, or reoperation for any cause, however, DP patients were more likely to be weight bearing in the twelve-week postoperative period ($p <0.001$) and return to their baseline ambulatory status ($p = 0.004$) compared to DFLP patients.

Conclusion: In our series DP in DFPF maintained coronal alignment with a low reoperation rate even with immediate weight bearing and DP patients regained baseline level of ambulation more reliably as compared to the DFLP group

The Effect of the Strengthen Opioid Misuse Prevention Act on Opiate Prescription Practices After Total Joint Replacement

Matthews, JH, Tully N, Shields JS

Introduction: Orthopaedic surgeons prescribe an estimated 7.7% of all opioid prescriptions in the United States, making them the third highest prescribers among physicians. In North Carolina, the Strengthen Opioid Misuse Prevention Act of 2017 (STOP Act) went into effect on January 1, 2018, with the intention of increasing the oversight of opioid prescriptions. In 2017, the year prior to enactment of the law, there were 1,953 reported opioid deaths in North Carolina, of which 659 cases were attributed to prescription opioids (6.5 deaths per 100,000 persons). Few studies have been published to assess the efficacy of the new law in preventing opioid over-prescription and its effects on the healthcare system. The purpose of this study was to review the effects of the STOP Act on patients undergoing total knee arthroplasty, total hip arthroplasty and hip hemiarthroplasty.

Methods: This study utilized a retrospective chart review of patients who underwent total knee arthroplasty, total hip arthroplasty, or hip hemiarthroplasty between January 1st and June 30th, 2017, before the enactment of the STOP Act, as well as from January 1st to June 30th, 2018, after the enactment of the STOP Act. Two hundred and eighty-nine patients were identified in the Pre-STOP Act group with 333 patients identified in the Post-STOP Act group. Variables of interest included demographics, amount of narcotic pain medications prescribed post-operatively, the number of calls and visits to the orthopedic clinic or emergency room due to post-operative pain, and the number of prescription refills for these patients. The data was analyzed using t-tests and Chi squared statistical analysis.

Results: There was a statistically significant decrease in average number of postoperative narcotic pills prescribed after the implementation of the STOP act (123.4 vs 63.6, $p < 0.001$). We found no significant difference between the number of calls or visits to clinic for pain control (30 vs 49, $p = 0.106$) or the number of post-operative emergency room visits for pain (19 vs 22, $p = 0.988$). However, there was a statistically significant increase in the average number of prescription refills requested and given (30 vs 45, $p < 0.005$).

Conclusion: After the STOP Act, the average number of opioid pills prescribed after knee and hip arthroplasty decreased by more than half, making the law efficacious in its goal to reduce opioid prescriptions written. There was no statistically significant increase in patient calls to clinic or visits to the emergency room for narcotic refills, suggesting the STOP Act did not have a significant increased burden on the healthcare system overall. Our results are in line with similar studies on opioid misuse prevention laws in Florida, which is further evidence that these forms of legislation may be successful in reducing opioid prescriptions nationally.

Contributions of Pubic Rami Fracture Morphology and Fixation to Pelvic Ring Stability in Type 1 Lateral Compression Injuries: A Biomechanical Cadaveric Study

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Introduction: Treatment of lateral compression type 1 (LC-1) injuries has historically been nonoperative with immediate weight-bearing. However, management of these injuries remains controversial, with reports of displacement at follow-up for nonoperatively managed LC-1 fractures. The goal of our study was to determine the effect of superior pubic ramus fracture morphology and fixation construct on pelvic stability.

Methods: Ten fresh-frozen cadaveric were transected into hemi-pelvises. Incomplete Denis type 1 sacral fractures were made. Hemi-pelvises were randomized to receive a transverse-type or oblique-type superior pubic ramus fracture with the contralateral hemi-pelvis receiving the opposing morphology. A lateral load to 135N was applied with an Instron materials testing machine and lateral displacement of the hemi-pelvis was recorded. Deflection and stiffness were calculated. Statistical analysis was conducted using a t test assuming unequal variances with an alpha = 0.05.

Results: Oblique-type superior pubic ramus fractures allowed more deflection compared with transverse-type fractures in the absence of fixation ($P = 0.018$). The posterior-only and combined anterior and posterior fixation configurations on average reduced deflection more than no fixation or anterior fixation only. In all fixation configuration cases, the average deflection for transverse-type fractures was less than that of the oblique-type fractures.

Conclusions: Our findings suggest that displacement of LC-1 pelvic injuries may be related to pubic rami fracture morphology. When looking at initial injury imaging, oblique-type pubic rami fractures may suggest an increased potential for displacement over time. In such cases, we recommend an examination under anesthesia to evaluate for underlying instability and consideration for fixation.

Non-Displaced Femoral Neck Fractures: Who Will Fail

Grimes C, Gwam C

Introduction: Despite better prognostic outcomes of non-displaced femoral neck fractures when compared to its displaced counterpart, many patients will still report poor outcomes after surgery fixation. Thus, using a prospectively collected database, we purposed to assess risk factors associated with post-operative complications and mortality in patients being treated for non-displaced femoral neck fractures. Specifically, we assessed risk factors associated with: 1) 30-day post-operative major complication; 2) 30-day post-operative minor complication; 3) 30-day return to the operating room and; 4) 30-day mortality.

Methods: A retrospective query was performed using the National Surgical Quality Improvement Program Database for Hip Fractures. Non-displaced or valgus impacted hip fractures were identified using the fracture pattern data element in the database. The query yielded a total of 1,778 patients. Logistic regression analyses were conducted to identify risk factors associated with the study endpoints. A concordance statistic was generated to analyze model strength.

Results: Our analysis demonstrated a good predictive model for all study endpoints. Factors associated with 30-day major complication included male gender (OR: 1.71; p=0.04), weight bearing post-op day 1 (OR: 0.47; p=0.003), pre-operative albumin level and BUN/Creatinine ratio. Factors associated with 30-day minor complication included post-operative delirium and pre-operative albumin level. Factors associated with 30-day mortality included weight bearing post-op day 1, post-operative delirium, preoperative functional status, and presence of disseminated cancer. Pre-operative albumin levels were the only available factor associated with 30-day return to the operating room of a non-displaced femoral neck fracture.

Conclusion: Our study identified factors associated with poor outcomes after surgical management for non-displaced or valgus impacted femoral neck fractures. Majority of orthopaedic surgeons, regardless of subspecialty, are expected to manage these injuries. We hope to use this data to help us identify specific risk factors that are correctable to improve the outcome of these patients. Additionally, use this data and further data points to develop a risk stratification algorithm to predict poor outcomes in this population. We believe our results will further assist in appropriately managing patients with non- displaced femoral neck fractures post surgery, as well as those patients who are treated non-operatively.

Liposomal Bupivacaine Use During Adolescent Idiopathic Scoliosis Surgery Decreases Postoperative Narcotic Usage

Alexander H. Jinnah, MD PhD; Rosser McCallie MD; Alejandro Marquez-Lara, MD PhD; Nicholas Tully, BS; Michael S. Hughes, MD; John Frino, MD

Introduction: Post-operative pain control in adolescent patients after undergoing posterior spinal fusion (PSF) for adolescent idiopathic scoliosis (AIS) can be difficult. Often a multi-modal pain regimen is implemented involving a combination of acetaminophen, muscle relaxers, neuropathic modulating drugs, and opioids. However, opioid use is not ideal due to side effects. Furthermore, with the ongoing opioid crisis minimizing the use of narcotics is of the utmost importance. Unfortunately, this can impede providing adequate pain control and decrease patient satisfaction. Liposomal Bupivicaine (LB) is a slowly released local anesthetic that can be injected during surgical closure, allowing a more prolonged effect. The purpose of this study was to identify if use of LB at the time of closure after PSF would reduce post-operative narcotic use compared to Bupivicaine Hydrochloride (BH).

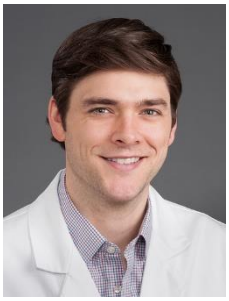
Methods: Beginning in November 2019 the senior author began using LB prior to closure in all AIS patients. The first 25 consecutive patients were matched with 25 AIS patients from the year prior to minimize changes in protocol and instrumentation and charts were retrospectivley reviewed. LB was administered at a dose of 266mg diluted in 40cc of normal saline and then injected into the paraspinal musculature evenly along the entire length of the incision. Patient demographics, curve severity, and surgical levels were compared. Postoperative outcomes including length of stay (LOS) and visual analogue scores (VAS) for pain (scale 0-10) were recorded. All patients were treated with the same postoperative protocol, which included a patient controlled analgesic (PCA) pump with hydromorphone. Morphine equivalent doses during the hospitalization were analyzed and compared between groups. A student T-test and Fisher Exact test were performed for continuous and categorical variables respectively. A p-value of 0.05 was set to denote statistical significance.

Results: There were 25 patients in each group with no significant difference in age, gender, body mass index, LOS, or number of levels fused. The LB group had significantly less morphine equivalent totals (11.97 vs 16.89, p=0.03), but there was no difference in VAS pain scores.

Conclusion: The use of LB in AIS patients undergoing PSF demonstrated no difference in pain scores compared to BH, however, there was a decrease in morphine equivalents used in the initial peri-operative period. The decrease in morphine equivalents among the LB group suggests that these patients reached a pain threshold requiring additional pain medication less frequently. However, future studies with larger samples sizes and double blinding must be done to prove causation. In conclusion, based on our results the use of LB decreased the morphine equivalents used in pediatric patients with AIS following PSF surgery.

Pediatric Orthopaedic Faculty

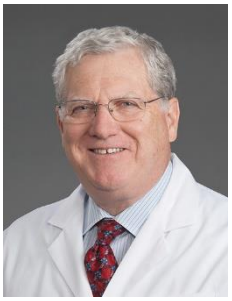
Dr. Marquez-Lara is a pediatric orthopaedic surgeon who was born and raised in Venezuela. He completed his medical degree in Venezuela before moving to the United States to further his education. He completed his orthopaedic residency at Wake Forest University and went on to complete a fellowship in pediatric orthopaedics at Cincinnati Children's Hospital. He is deeply committed to helping children of all ages recover from injuries and get back to doing the things they love. He has a particular interest in hip preservation, limb deformity, knee instability, cerebral palsy, and gait mechanics. Dr. Marquez-Lara is also passionate about the role that nutrition and the microbiome play in our health and recovery from injury. He believes that a holistic approach to care is essential to achieve the best outcomes for his patients.



Dr. Hughes is a pediatric orthopaedic surgeons with a diverse practice that ranges from congenital and acquired deformities, trauma and fracture care, foot and ankle surgery, limb deficiency, neuromuscular care, and spinal deformity. He has a deep passion for spinal deformity, and has been actively researching and working in the field from the start of his time in orthopaedic surgery. He has authored book chapters on congenital scoliosis and AIS, as well as peer-Reviewed articles on EOS and AIS. He is a member of the Scoliosis Research Society and the Pediatric Spine Study Group, and serves on the editorial board for Spine Deformity Journal.

Dr. Hughes also has an interest in education and surgical training, He has served on POSNA Core Curriculum Committee and is developing a regional resident and follow training course, the South Eastern Pediatric Orthopaedics Course (SEPOC).

When not at the hospital, you can find him outside with his family, where he loves to get lost in the woods on trail runs.



Dr. Koman is a tenured professor and Chair Emeritus of the *Department of Orthopaedic Surgery and Rehabilitation*. He has 44 years of experience as a pediatric orthopedic surgeon and is a member the **Pediatric Orthopaedic Society of North America** from which he received the *Arthur H Huene Award* "in recognition of his outstanding contribution to pediatric orthopedics and in support of future endeavors." In addition he received one of two *Kappa Delta / Clinical Research Award* for his seminal work in the basic and clinical applications of botulinum toxins with an emphasis on pediatric uses in cerebral palsy. He has presented over 1,500 lectures in 30 states and 10 countries, written more than 250 scientific papers and chapters, has 3 patents and has received over $5,000,000 in research funding. He pioneered the use of botulinum toxin as a modality to manage cerebral palsy and is recognized for his expertise in the non-operative and operative management of congenital hand disorders, cerebral palsy, pediatric brachial plexus, pediatric trauma, pediatric vascular compromise and pediatric nerve injuries.

Dr. Mooney has over 30 years of experience in the clinical practice of pediatric orthopaedic surgery. His areas of particular interest include management of spinal deformities in skeletally immature patients and the operative care of pediatric orthopaedic trauma patients. In addition, he has extensive experience in surgical and nonsurgical care of the orthopaedic aspects of Cerebral Palsy. Prior to returning to Winston-Salem, he was the chief of pediatric orthopaedic surgery at the Children's Hospital of Michigan, the Medical University of South Carolina, and the Chief of Staff at the Shriners Hospital for Children in Springfield, MA. He is a talentless, but enthusiastic golfer, and an ever-suffering fan of all Detroit professional sports teams as well as a proud Stanford University alumnus.

Dr. Ravish has over 13 years of experience has a pediatrician specializing in non-operative pediatric orthopedics and sports medicine. His special interests include Ponseti clubfoot management, fractures and sports injuries, non-operative scoliosis management and the evaluation and treatment of developmental hip dysplasia. Dr. Ravish is heavily involved in resident education, focused on pediatric MSK learning for our primary care residents. He and his family have called Winston-Salem home since 2006.

Dr. Frino is a pediatric orthopaedic surgeon who has been with Brenner Children's Hospital at Wake Forest Baptist Health since 2006. His practice is as diverse as his many valued patients. From congenital abnormalities to trauma and fracture care, he is deeply committed to helping children of all ages recover and return them to "being a kid". He has a deep interest in spinal deformities and has been diligently working in this field from the beginning of his time as an orthopaedic surgeon. He has authored numerous book chapters and peer-reviewed articles on the adolescent spine. Most recently he was the invited presenter at the Stryker Winter Deformity Course. He is a member of the AAOS, ABOS, POSNA, Scoliosis Research Society, and is a journal reviewer for the Journal of Surgical Orthopaedic Advances, as well as many others.

Dr. Frino also has a great interest in educating and training future surgeons. He has been taking time to journey to Guatemala on medical mission trips helping many, many patients there.

When away from the hospital, he enjoys music and time with his family, and wishes his daughter lived closer.

Dr. Kolaski has over 30 years of experience treating children with special needs. When she came to Wake Forest in 2003, she focused her practice on the management of children with musculoskeletal problems related to various neuromuscular disorders, in particular cerebral palsy. She specializes in the multi-disciplinary treatment of spasticity with a range of treatment options. She works closely with therapists and colleagues to coordinate care and optimize outcomes of patients needing non-surgical as well as orthopedic and neurosurgical interventions. Beyond her clinical interests, Dr. Kolaski has a strong academic interest in evidence-based medicine and the methodology for evidence syntheses.

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